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PVDF hollow fibre membranes with interconnected bicontinuous structures produced via immersion precipitation technique

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Wastewater treatment and water purification have become much more important these days; consequently, the use of membrane separation process in this field has attracted a lot of attention. Different polymers such as Poly(vinylidene fluoride) PVDF, poly(acrylonitrile) (PAN), polysulfone (PS), poly(ethersulfone) (PESf), polypropylene (PP) and poly(tetrafluoroethylene) (PTFE) are used to produce commercial polymeric membranes. Of theses, Poly(vinylidene fluoride) (PVDF) is one of the best candidate for commercial membrane production due to its excellent properties such as high mechanical strength, chemical resistance and thermal stability. Moreover, since PVDF polymer can be dissolved in common organic solvents such as Dimethylacetamide (DMAc), N-Methyl-2-pyrrolidone (NMP) and Triethyl phosphate (TEP), PVDF membranes can be produced via inexpensive immersion precipitation technique. The use of PVDF membranes in wastewater and water management has considerably increased due to the fact that PVDF membranes have a life span between 3 to 5 years for general applications; however many of them are still functional for 5-10 years in the water supply fields [1].

Many investigations have been focused strongly on the fundamental membrane morphological studies via the phase inversion process and the development of hollow fibre membranes [2-7]. Membranes from semi-crystalline polymers such as PVDF can be produced through two mechanisms during the immersion precipitation technique i.e. crystallization and liquid-liquid demixing. Membranes formed from liquid-liquid demixing, which occurs in a fast phase separation process, exhibit cellular pore structures i.e. fingers and sponges; whereas, membranes with interlinked crystalline structures formed via the crystallisation mechanism in a slow phase separation process [8, 9]. Interconnected bicontinuous structure, rather than finger like pores, for micro- or ultra- filtration membranes seems to prevail due to the significant improvement of flux and mechanical properties. PVDF membrane with such structure has been achieved by using thermally induced phase separation (TIPS). Also by controlling the immersion precipitation process, PVDF flat sheet membrane with interconnected bicontinuous structure was obtained [10].

TEP has known as a relatively weak solvent for PVDF and presents a very slow phase separation during the membrane formation. PVDF can be completely dissolved in TEP at high temperatures, but by reducing the temperature the viscosity of the PVDF/TEP solution increases until the solution becomes gel. PVDF hollow fibre membranes with interconnected bicontinuous structure were obtained using TEP as the solvent via a single-step phase separation method during a highly controlled phase inversion. Due to the formation of thick dense skin layers the hollow fibre membranes spun from the PVDF/TEP solution exhibited almost no water flux but showed excellent mechanical properties. In order to eliminate the dense skin layers and enhance the water flux, Poly(ethylene glycol) (PEG) with two different molecular weights (400 Da and 6000 Da) were used as additives. By using PEG as additive in the spinning dope solution, the flux of the spun hollow fibres was significantly improved while the desirable interconnected structure remained almost unchanged; however, the mechanical properties were deteriorated. Figure 1 shows the structure of different PVDF hollow fibres, A: PVDF/DMAc with fingers and sponges, B and C: interconnected structure by using TEP as the solvent.

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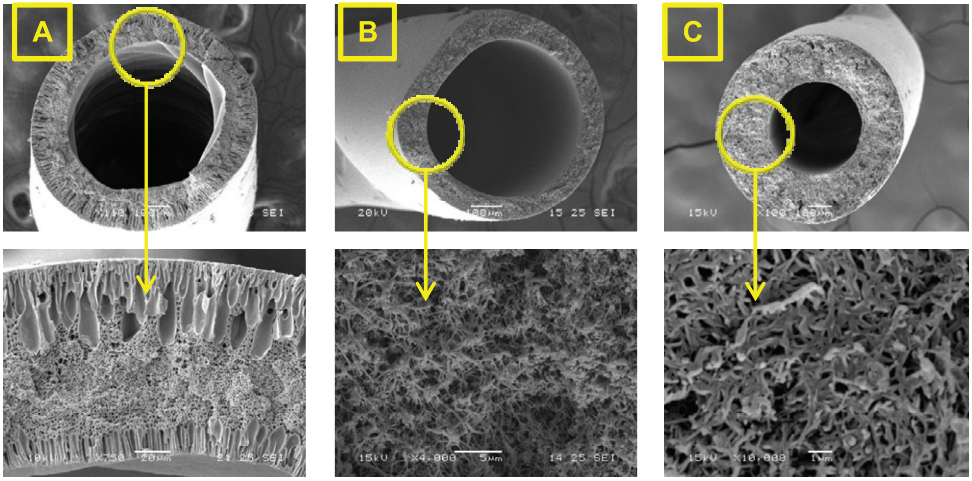

Fig. 1: PVDF hollow fibres spun from different spinning dopes: A: PVDF/DMAc, B: PVDF/TEP, C: PVDF/PEG/TEP

By using different PEG molecular weight additives (400 Da and 6000 Da) and changing spinning parameters a number of different hollow fibres with different properties and performance (form the flux of about 137 ($Lm^{-2}h^{-1}$) and MWCO of 150 kDa to the flux of 204 ($Lm^{-2}h^{-1}$) and MWCO of about 200 kDa) were obtained. The results suggested that the produced hollow fibres from PVDF/PEG/TEP solutions are in the range of ultrafiltration and suitable to be used for water and waste water applications.

References:

1. Advanced Membrane Technology and Applications: John Wiley & Sons, Inc., 2008.
2. Dongliang Wang, K.Li and W. K. Teo, J of Membrane Sci., 178 (2000) 13-23.
3. J.F. Kong and K. Li, J. of App. Polymer Sci., 81 (2001) 1643-1653.
4. M.L. Yeow, Y.T. Liu and K. Li, J. of App. Polymer Sci., 90(8) (2003) 2150-2155.
5. Fu Liu, M.R. Moghareh Abed, K. Li, J. of Membrane Sci., 366 (2011) 97-103.
6. Fu Liu, N. Hashim, Yutie Liu, M.R. Moghareh Abed, K. Li J. of Membrane Sci., 375 (2011) 1-27
7. M.L. Yeow, Y.T. Liu and K. Li, J. Membrane Sci., 258(2005) 16-2
8. D.J. Lin, K. Beltsios, C.L. Chang, L.P. Cheng, J. of Polymer Sci. Part B-Polymer Physics, 41 (2003), 1578–1588
9. D.J. Lin, C.L. Chang, T.C. Chen, L.P. Cheng, J. of Polymer Sci. Part B-Polymer Physics, 42 (2004), 830–842
10. D.J. Lin, H.H. Chang, T.C. Chen, Y.C. Lee and L.P. Cheng, J. Membrane Sci., 112 (1996), 29–39

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